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ABSTRACT

An experiment was designed to test the hypothesis that abstract materials increase accuracy in solving categorical syllogisms. In an attempt to encourage subjects to reason their way through the problems rather than to make judgments about the truth or desirability of the proffered conclusions, the premises were composed of familiar words in strange combinations. Imagery/concreteness ratings were therefore based on the premise nouns, not on the premises considered as sentences. The syllogisms were designed to cover extreme and moderate levels of concreteness and ambiguity, and to include both negative and completely positive problems. Subjects included 150 undergraduate students enrolled in a university public speaking course. Students were given a booklet that contained the same 18 categorical syllogisms, ordered randomly, and were told that their task was to choose one from a list of possible valid conclusions. The results, when compared with the results from three earlier studies, showed that (1) accuracy dropped as imagery increased for high ambiguity positives, with the opposite effect occurring for low ambiguity negatives; (2) negative syllogisms were harder to solve for all low and medium ambiguity syllogisms, with the opposite effect for high ambiguity problems; and (3) accuracy dropped as ambiguity increased for positive syllogisms and was not as clearly supported for negative problems. (HOD)

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THE EFFECTS OF IMAGERY, NEGATIVITY AND AMBIGUITY ON SYLLOGISM DIFFICULTY

By

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Though none of them provides experimental evidence for the claim, several writers (Horowitz, 1970, p. 291; Paivio, 1971; Wyer & Carlston, 1979, pp. 41-42; Hample, in press) assert that logic's realm is the verbal and abstract, while imagic and concrete materials are processed associationally, hence alogically. The most coherent explanation for this hypothesis is provided by dual coding theory (Paivio, 1971). Dual coding theories hold that humans have two coordinated but distinct ways of processing information. One, for abstract verbal materials, is linear and sequential. The other is called into play by concrete, highly imageable information, and is nonlinear and associational. Concrete words are ordinarily dual coded--that is, they may be processed in the imagic (nonverbal) system, but they usually pass in and out through the abstract modality, and so must be catalogued in both. Begg (1972), for instance, reports evidence that a concrete adjective-noun phrase will be stored as a single coherent image, while an abstract phrase will be handled only as a string of two words.

Reasoning--moving from evidence to conclusion--can occur in either the verbal or nonverbal modality. Logically valid conclusions may result (perhaps by accident) from any kind of thinking. But to <u>do</u> logic requires that the reasoning follow a certain verbal sequence from premise to conclusion. So a corollary of dual coding theory is that for logical problems, verbal processing is natural, while nonverbal processing is not.

Large bodies of work are available on both imagery (e.g., Paivio, 1971; Segal, 1971; Kosslyn, 1980) and reasoning (e.g., Wason & Johnson-Laird, 1972; Falmagne, 1975; Johnson-Laird & Wason, 1977; Revlin & Mayer, 1978), but these traditions do not seem to have crossed in such a way as to provide a direct test of this hypothesis. The available evidence is not univocal. The supposition that concrete problems should be easier to solve is supported by the well-known findings that concrete stimuli are easier to remember (e.g., Barresi & Silbert, 1976; Paivio, 1971), even for some complex problems with high information

loads (Petelle & Petelle, Note 2). This may be due to easier comprehension of concrete passages (e.g., Barclay, 1973). But in a study of the time required to verify pragmatic (not logical) implications of sentences, Belmore, Yates, Bellack, Jones and Rosenquist (1982) report no advantage for concrete material. If concrete problems are easier to solve, they should also be dealt with more quickly, and this was not the case.

Wason and Johnson-Laird (1972, ch.) review experiments showing that people have more difficulty with extremely abstract material than with familiar concrete problems. Much of this work, however, relies on purely symbolic premises (e.g., "All A is B") rather than ordinary but highly abstract premises to represent the abstract conditions in the studies. Consequently, the comparisons are really between concrete and symbolic materials, not between concrete and abstract. Other research dealing with logical reasoning is no more clear-cut on these issues. Linear syllogisms seem to require imaginal representation in order to be solved (DeSoto, London & Handel, 1965; Sternberg, 1980). Other kinds of syllogisms might conceivably be handled in a similar way (for a plausible example, see Cox, 1978). In fact, concreteness seems to improve performance on both linear syllogisms (Williams, 1979) and chain reasoning problems (Cox, 1978). However, concreteness does not yield any advantage in causal reasoning (Schustak & Sternberg, 1980), conditional syllogisms (Manktelow & Evans, 1979) or a practical problem solving task (Kaufman & Bengtsson, 1980). Of course, operationalizations of high and low concreteness vary among these studies, as do the particular incarnations of reasoning. Nonetheless, no simple way to sort out these findings immediately suggests itself, and the corollary to dual coding theory (viz., that the verbal modality is more adapted to logical reasoning) cannot be said to have been clearly evaluated by previous work.

The present experiment is designed to test the hypothesis that abstract materials increase accuracy in solving categorical syllogisms. In an attempt to

encourage subjects to reason their way through the problems, rather than to make judgments about the truth or desirability of the proffered conclusions (see Morgan & Morton, 1944; Gordon, 1953; Mehling, 1959; McGuire, 1960), the premises were composed of familiar words in strange combinations. Imagery/concreteness ratings were therefore based on the premise nouns, not on the premises considered as sentences. By giving subjects a choice of conclusions (one valid, two invalid), a straightforward measure of solution accuracy was obtained.

Some syllogisms are considerably easier than others, and people may use different reasoning strategies on more difficult problems. Two additional variables were therefore added to the design in order to ensure that task difficulty varied considerably. The first of these is negation--whether or not the premises contain a "not." Negative premises make problems more difficult (Wason & Johnson-Laird, 1972, chs. 3-5). This result has appeared for categorical syllogisms (Helsabeck, 1975; Roberge & Mason, 1978), for linear syllogisms (Williams, 1979) and for conditional syllogisms as well (Roberge & Mason, 1978; Leahy, 1980; Jansson, 1977; Evans, 1972). Even in a recent study designed to reduce the effects of negation on latency and accuracy, negatives still take longer and generate more errors than positives (Valle Arroyo, 1982). So syllogisms containing negatives ought to be harder than those which do not.

Premise ambiguity (Steinfatt, Miller & Bettinghaus, 1974; Ceraso & Provitera, 1971; Jackson, note 1) is also an important predictor of task difficulty. The basic idea here is that premises (and their combinations) may mean several things. For instance, "all As are B" can mean either that "A and B are identical, with all As being Bs and all Bs being As," or that "all As are a part of B, but some Bs are not As." Steinfatt et al (1974) provide an index of ambugity based on this principle. Previous work has shown that ambiguity

predicts error rate (Steinfatt, et al, 1974; Ceraso & Provitera, 1971), and that result should appear here as well.

The syllogisms for this experiment are designed to cover extreme and moderate levels of concreteness and ambiguity, and to include both negative and completely positive problems. Though the dangers of generalizing from one kind of logical problem to another are probably obvious by now, this study should constitute a solid test of the three hypotheses--that concreteness, negation and ambiguity should raise error rates--for categorical syllogisms.

Method

Subjects were 150 undergraduates enrolled in a university-required public speaking course at the author's institution. Students were told that their task was to choose a valid conclusion from a list of possible ones. "Validity" was defined, and the instructions also gave two example of valid syllogisms--one in which the conclusion was true, and another in which the conclusion was obviously false. The distinction between "true" and "valid" was discussed briefly, and "some" was defined as meaning "at least some." Students were warned to expect bizarre problems: "This is to help you concentrate on picking the valid conclusion, instead of looking for true ones."

Each student was given a booklet. Every booklet contained the same eighteen categorical syllogisms, ordered randomly. The problems represented two levels of negation, positive (P) and negative (N), three levels of imagery (HI, MI and LI) and three levels of ambiguity (HA, MA and LA). The negative problems each had only one premise negated. In one of these syllogisms, the first premise contained the negative, and in the other two the second premise did (cf. Evans, 1972). (In all six problems, the usual distinction between major and minor premises is not important since both premises tend to be equally general: e.g.,

the high ambiguity medium imagery positive problem was "Some dreams are henchmen. Some pollution is a dream.") High imagery syllogisms used nouns which all had ratings of 6.50 or higher, medium imagery terms were between 4.50 and 5.00, and low imagery words all rated below 3.00 (Paivio, Yuille & Madigan, 1968; Williams, 1979, reports a correlation of .91 between his imagery ratings and those of Paivio et al). Imagery is almost completely confounded with concreteness, and the two terms will be treated as synonyms in this report (r=.83--Paivio, et al, 1968; cf. Richardson, 1980). Imagery is also closely associated with meaningfulness (r is about .70--Paivio, 1971, pp. 80-81). No word was used twice in the instrument, and all were selected to be familiar to college students. Eighteen nouns were used in each imagery condition. For high imagery, 14 have a Thorndike-Lorge frequency of A or AA; for medium imagery 7 are A or AA; for low imagery 8 are A or AA (Paivio, et al, 1968). Ambiguity ratings were taken from Steinfatt, et al (1974). The low ambiguity problems have ratings of 2 and 4, the medium ambiguity syllogisms' scores are 12 and 16, and the high ambiguity figures are 76 and 80. Readers should note that "medium" ambiguity is far closer to low ambiguity than high (see Steinfatt, et al, 1974). Six sets of premise types (A, E, I or O) and figure (1, 2, 3 or 4) were used: II1, AI1*, AA1*, I03, EI1*, and AE2*. The asterisked syllogisms have at least one possible valid conclusion. Each item appeared once in each imagery condition, suitably reworded.

Every problem consisted of the two premises, followed by three conclusion choices. The third choice was always "Neither is valid." The other two answers were a valid conclusion (whenever one was available) and a conclusion which would be chosen by a person susceptible to atmosphere-effect errors (Wilkins, 1928; Woodworth & Sells, 1935; see Begg & Denny, 1969; Henle, 1962; Chapman & Chapman, 1959; and Roberge, 1970, for other possible explanations of this robust effect). If the syllogism had no valid solution, then two atmosphere effect

answers were listed. The choices of conclusion were designed to make errors attractive. Correct substantive conclusions were distributed randomly between the first two answer positions, with the restriction that all three positions be correct one third of the time. The dependent variable is whether or not the syllogism is solved correctly. After responding to the eighteen items, students indicated their year in school, gender and whether they had taken a logic course.

The materials were restricted to only eighteen items to avoid fatigue effects. In fact, the study required only about fifteen minutes to complete. After handing in their materials, students were debriefed.

Results

Reliability

The study's design does not allow for a direct measure of reliability, since no dependent variable is repeated or parallelled in the testing instrument. However, a lower limit for reliability may be obtained by considering the syllogisms to be alternative forms of one another. This was done, and a standardized item alpha of .67 resulted. Since this value reflects comparisons of responses to different tasks, the true reliability for any one type of syllogism would presumably be higher, provided that all other conditions were the same. Consequently, the data are judged to be sufficiently reliable for further analysis.

Covariates

Each respondent indicated gender, year in school and whether or not s/he had taken a logic class. Each of these three variables was tested as a between subjects factor, and none produced a significant main effect (for gender, $F=.04$; for year in school, $F=1.21$, $p>.30$; for logic class, $F=.31$). Logic class failed to interact significantly with any of the study's main variables, either alone

or in combination. Year in school participated in two significant interactions, negativity X year ($F=2.70$, $p<.05$) and negativity X ambiguity X year ($F=2.55$, $p<.05$). The ambiguity X gender interaction was also significant ($F=5.15$, $p<.01$). These three interactions were the only significant findings of the 24 F tests involving gender, year in school and logic class. These results did not warrant using any of the demographic variables as covariates, both because of the likelihood that one or more of the significant results is spurious (see Steinfatt, 1979) and because of the limited theoretical interest of any of the three interactions.

Hypotheses

A repeated measures ANOVA was applied to the remaining 2x3x3 design, and results are presented in Table 1. All main effects are significant, but

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INSERT TABLE 1

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essentially uninterpretable because the interactions are also significant. Effect size (ω^2) was calculated according to the conservative procedures (assuming additivity) outlined by Dodd and Schultz (1973; a more liberal procedure is given by Gaebelein & Soderquist, 1978). The whole model explains 13.6% of variance in the dependent variable. While this is lower than one might wish (it corresponds to $R=.369$), the ω^2 is naturally depressed by several things. Logical ability was presumably an important factor in students' performances (54.3% of all answers were correct) but is not included in the explanatory part of the model. A related consideration is the between subjects variation, which contains differences in peoples' logical abilities and other unspecified personal variables; this source of variance is included in the denominator of the ω^2 calculation, reducing the final figures. This study's three variable system is by no means a full model of syllogism solving behavior, but it does specify some substantively important and theoretically interesting influences

on thought.

The imagery results (fig. 1) reflect the triple interaction. The original prediction--that accuracy would drop as imagery increases--is supported only for

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INSERT FIGURE 1

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the positive high ambiguity syllogisms. Exactly the opposite effect occurs with low ambiguity negative problems: accuracy increases as imagery does. The other conditions do not show clear effects in either direction. Figure 1 also displays an interaction between ambiguity and negativity: positive syllogisms are easier than negative ones, with the notable exception of the high ambiguity positives, which are hardest of all.

This ambiguity X negation interaction also appears in figure 2, which is designed to show the negativity results. The prediction that positive problems

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INSERT FIGURE 2

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are easier is supported for all low and medium ambiguity conditions. But all high ambiguity problems fail to support the hypothesis. The triple interaction is apparent again, in the differences between the imagery conditions when crossed with high ambiguity: Low imagery problems are unaffected by negativity, medium imagery shows a small-to-moderate effect (mean difference of about 7% in accuracy), and high imagery syllogisms exhibit a large contrast--24%--between positive and negative syllogisms. The high ambiguity effect, of course, is exactly opposite of the hypothesis. Note that of all the supportive conditions, the negation effect is weakest for high imagery; the reversal of the negativity prediction is also strongest for high imagery. Figure 2 also indicates that the imagery effect occurs more or less as predicted with positive propositions, but not with the negative ones.

The ambiguity results are most easily seen in figure 3. The clearest effect is the interaction between ambiguity and negativity. The predicted

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INSERT FIGURE 3

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ambiguity effect is strongly marked for the positive problems, but is only weakly present with negative syllogisms. As the graph shows, accuracy drops by large margins in all three positive conditions, but only declines for high and medium imagery for negative syllogisms (and these latter drops are smaller than those for positive premises). The hypothesized result does in fact occur throughout most conditions, but its strength is due largely to the positive syllogism results. Interestingly, negative problems are easier to solve than positive ones when premises are highly ambiguous.

The complexity of these results may justify repetition of the main findings:

1. Imagery (H_1: accuracy drops as imagery increases):
   a. The hypothesis is supported for high ambiguity positive problems.
   b. The opposite effect occurs with low ambiguity negative syllogisms.
2. Negativity (H_2: negative syllogisms are harder to solve):
   a. The hypothesis is supported for all low and medium ambiguity problems.
   b. The opposite effect occurs with high ambiguity syllogisms.
3. Ambiguity (H_3: accuracy drops as ambiguity increases):
   a. The hypothesis is strongly supported for positive syllogisms.
   b. The hypothesis is not as clearly supported for negative problems.

The results indicate that the simple main effects which were predicted must be qualified in important respects.

Reanalysis of Earlier Studies

These results are obviously not in accord with the hypotheses made in the first section of this paper. The appearance of the interactions invites the suspicion that similar results may have been unnoticed in previous investigations, especially considering that all the main effects in this experiment were statistically significant. Reanalysis of earlier work can cast some light on various of this paper's findings, though it will be necessary to note carefully the design differences among the experiments. Three important earlier studies--Wilkins (1928), Steinfatt, et al (1974) and Ceraso and Provitera (1971)--report their results in enough detail to make at least partial reanalysis possible.

Wilkins (1928)

Wilkins (1928) gave two parallel forms of a syllogism test to 81 undergraduates. Each form had four parts: one phrased the problems in familiar terms, the second used symbols (e.g., A, B, X, Y) in the same problems, the third featured unfamiliar or nonsense words (e.g., "echinoidea," "gyrofantastices") and the fourth involved familiar terms arranged so that invalid conclusions were attractive. For this reanalysis, data from both forms of the test are combined. The first (familiar) version is regarded as concrete, which inspection of the syllogisms makes quite plausible. The third version is used to represent the abstract condition. This equivalence is somewhat dubious because the "unfamiliar" words are so long and odd looking that respondents may not have processed them as words at all. This writer's reflexive reaction to those premises was to substitute symbols for the words, and in fact Wilkins observed a high association (r=.805) between the unfamiliar and symbolic versions. Even so, the "unfamiliar" version is a better representation of high abstractness than a symbolic version. Data from the symbolic and suggestive versions are not reanalyzed. Wilkins' syllogisms were classified as having negative premises or

not, and ambiguity ratings were taken from Steinfatt, et al (1974). Low ambiguity scores were from 2 to 8, medium from 10 to 20, and high from 70 to 80. Thus, all three variables from the present experiment find close analogues in Wilkins' design. Many items from Wilkins' instrument, however, are excluded here: none of her one-premise implication problems are used, all linear syllogisms are omitted, no problem using "most" or "only" is kept, the problem which did not have the same (formal) choices of conclusions on the concrete and abstract versions is dropped, and syllogisms for which Stienfatt, et al (1974) do not give an ambiguity rating are also excluded. In all, data for 17 of the original 40 problems are used, allowing fairly close comparisons with the present study.

Results of the reanalysis are reported in table 2, and are graphed in figures 4, 5 and 6. The imagery (i.e., concreteness) results show that ease of solution increases as imagery does (see fig. 4). This is in clear contradition to the original hypothesis. Comparison of figures 1 and 4 reveals some simil-

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INSERT TABLE 2, FIGURES 4, 5 & 6

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arity in the graphs for the negative premise problems, but little for the affirmative ones. In particular, the interesting high ambiguity positive line of figure 1 is part of the general pattern in figure 4. Figure 4 does not appear to replicate the interactions of figure 1. This may be somehow related to Wilkins' respondents' better performance on the test, or to the different syllogisms used (though the HAP problem happened to be the same as in the present study).

The negativity results (fig. 5) show some similarity to those in figure 2. In both, positive problems are easier for low and medium ambiguity syllogisms, but negative premises are actually easier for the high ambiguity conditions.

Though the overall negativity X ambiguity interaction is replicated, the contribution of imagery is different. In figure 2, the dramatic preference for negation appears for high imagery high ambiguity, with low imagery high ambiguity showing no effect, while in figure 5 the reverse is true.

A comparison of the ambiguity results (figs. 3 & 6) reveals the same negativity X ambiguity interaction again. An increase in ambiguity depresses solution rates for affirmative problems, but makes little or no difference with negative premises. Though figure 3 shows the interaction more sharply, the overall pattern in figure 6 is similar enough to claim that the effect is replicated there.

In sum, Wilkins' data 1) mitigate against this study's imagery hypothesis and do not replicate the only supportive condition (high ambiguity positive); 2) replicate this study's findings on negativity; and 3) replicate the related ambiguity results as well.

Steinfatt, et al (1974)

Steinfatt, et al (1974) asked 207 undergraduates to respond to 21 syllogisms, once with meaningful CVCs (e.g., BOY, FAR) and once with low meaningful ones (e.g., XOM, RYW). Each of these 42 premise combinations was paired with two different conclusions yielding a total of 84 problems. Students had to say if the conclusion followed or not. Respondents also filled out a dogmatism scale, which is irrelevant here. Reanalysis of the data combines results from the two meaningfulness conditions, which did not produce different results in the original report. The meaningfulness manipulation might be regarded as similar to the present abstract/concrete contrast, but for two problems: all the meaningful terms are not nouns, which are considerably more concrete and higher in imagery than other types of words (Paivio, 1971, p. 80), and the low meaningful CVCs are not words at all. In contrast to Wilkins (1928), where at least the concrete condition was clearly recognizable, Steinfatt et al's manipulation does not

allow a plain identification for either condition. The ambiguity and negativity conditions, however, are exactly the same as in the present study. Reanalysis of the data is confined to those syllogisms used in both studies, and should therefore allow very close comparisons, once the differences in content (concrete, abstract, meaningful, not meaningful) are noted.

Results of the reanalysis are in table 3 and figures 7 and 8. Figure 7 shows the negativity results, and should be compared to figures 5 and 2.

INSERT TABLE 3, FIGURES 7 & 8

The Steinfatt et al data clearly show the negativity X ambiguity interaction present in the other two graphs. Affirmative problems are easier in the low and medium ambiguity conditions, but negative syllogisms are easier if they have high ambiguity.

Ambiguity results are in figure 8, which compares to figures 6 and 3. The striking pattern of figure 3, which is less dramatically present in figure 6, is again strongly apparent in figure 8. Increases in ambiguity reduce overall solution accuracy, as Steinfatt et al report, but this effect is much more clearly marked for the positive problems than for those having negative premises.

The Steinfatt et al data have no bearing on imagery, but are strongly supportive of the previous negativity and ambiguity findings.

Ceraso and Provitera (1971)

Ceraso and Provitera (1971) base their experiment on the observation that many logically-stated premises are ambiguous. This is the same principle underlying the ambiguity ratings of Steinfatt et al (1974) which are used in the present experiment. The 80 undergraduates used in this study were given either traditionally-worded syllogisms or more elaborately-worded versions designed to eliminate premise ambiguity. These conditions will be regarded as high and low

ambiguity, respectively, in the reanalysis. Of Ceraso and Provitera's 13 problems, three used negatives, allowing the usual positive/negative contrast. The data should probably be regarded as all representing a concrete, high imagery condition, since students worked with premises referring to wooden blocks, physical examples of which were displayed.

Results of the reanalysis are in table 4 and figures 9 and 10. Figures 9 and 10 show the now-familiar negativity X ambiguity interaction. Negative

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INSERT TABLE 4, FIGURES 9 & 10

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premise problems are much more easily solved if the syllogism has high ambiguity (figs. 9, 7, 5 and 2). In contrast to the earlier reports, figure 9 does not show an actual improvement in solution accuracy due to positive premises under low ambiguity conditions, but this half of the effect is also weak in the Wilkins (1928) data (fig. 5). Figure 10 shows the same interaction as clearly as figures 8 and 3, reconfirming them while placing the less sharp results of figure 6 in a more certain light.

The Steinfatt et al (1974) results could say nothing about the most important differences between the present study and Wilkins' (1928)--the divergence (cf. figs 1 & 4) regarding imagery. Particularly at issue is the high ambiguity positive line, which looks anomalous in figure 1 but not in figure 4. Regarding all of Ceraso and Provitera's data as reflecting the high imagery condition of this and Wilkins' studies, support appears for the results in figure 1. Lumping together similar scores, featuring the key high ambiguity positive results, and using only the high imagery conditions from figures 1 and 4, we get these orderings:

Wilkins:	(LAN & LAP)>(HAN & MAP)=<u>HAP</u>>MAN
Ceraso & Provitera:	(LAP & LAN & HAN)><u>HAP</u>
present study:	(MAP & LAP)>(LAN & MAN & HAN)><u>HAP</u>

The considerable similarity between the findings of Ceraso and Provitera and the current experiment is plain, and a fair match with even the divergent Wilkins results appears. The Ceraso and Provitera data therefore offer a partial replication of the original imagery X ambiguity X negativity interaction, and do so for the critical high ambiguity positive condition.

Conclusion to the Reanalyses

Taking the results of all three reanalyses together, we have considerable support for the original findings. Following the results outline from the previous section, we now have:

1. Imagery (H_1: accuracy drops as imagery increases):
   a. H_1 is supported for high ambiguity positives. Not supported by Wilkins; supported by Ceraso & Provitera.
   b. The opposite effect occurs for low ambiguity negatives. Supported by Wilkins; no effect in Ceraso & Provitera.
2. Negativity (H_2: negative syllogisms are harder to solve):
   a. H_2 is supported for all low and medium ambiguity syllogisms. Supported by Wilkins and Steinratt, et al; no effect in Ceraso & Provitera.
   b. The opposite effect occurs with high ambiguity problems. Supported by all three reanalyses.
3. Ambiguity (H_3: accuracy drops as ambiguity increases):
   a. H_3 is strongly supported for positive syllogisms. Supported by all three reanalyses.
   b. H_3 is not as clearly supported for negative problems. Also true of all three reanalyses.

All this together is strong and consistent evidence that claims about imagery, negativity and ambiguity must be mutually qualified. The complexity of these results needs to be reflected in our theories.

Discussion

The burden of this section is to provide explanations for the complicated results of the four studies. Two points seem particularly interesting. First, in regard to imagery, how shall we understand the high ambiguity positive results? For the most part, accuracy improved whenever imagery increased, but not for the high ambiguity positives. Secondly, how can inclusion of a negative actually make a problem easier? This happened for high ambiguity problems throughout the studies, and is in clear contrast to well-established findings on negation. Only by dealing coherently with these issues can an explanation hope to account for the whole pattern of results.

Two explanations are plausible enough to deserve mention here, even though both presently seem inadequate. First, one might claim that concreteness always confers an accuracy increment. This hypothesis, as we have seen, is consistent with the results of experiments on memory and comprehension, and it could account for all the Wilkins data. It is not, however, always borne out in reasoning studies. In particular, it fails to account for the high ambiguity positive result reported here, in which an increase in imagery made the syllogism much harder. The second plausible account revolves around the "no solution" problems. Perhaps these are simply harder than those which have valid substantive conclusions. Subjects were presumably twice as tempted by atmosphere effect answers for the two no solution syllogisms. High ambiguity positive is one of these problems, and high ambiguity negative is the other. These were two of the most difficult problems in the studies, but they were not always the hardest (see tables 1, 2 & 4). The real problem with the no solution hypothesis is that not having a valid solution is almost completely confounded with ambiguity, particular atmospheres, and so forth. Certainly the present data cannot separate these variables. And on theoretical grounds, ambiguity is a preferable explanation, for it is a continuous variable and possesses considerable face validity. Besides,

the no solution explanation is incomplete: while it indicates why high ambiguity positives are hard with high imagery (fig. 1), it does not explain why various valid solution problems have about the same solution rates as high ambiguity positive and high ambiguity negative (viz., low ambiguity negative with low imagery in fig. 1, medium ambiguity negative and medium ambiguity positive with low imagery and medium ambiguity negative with high imagery in fig. 4, and low ambiguity negative in fig. 9). And in company with the concreteness hypothesis, it has nothing to say about the negation results.

Nonetheless, a coherent post hoc explanation for most of the key results may be possible. The account rests on several propositions. First, high ambiguity problems are harder. This is almost universally true (see figs. 3, 6, 8 & 10); though results showed several significant interactions, the main effect hardly seems open to dispute. The mechanism by which ambiguity creates difficulty is not clear: it seems unlikely, for instance, that the main reason that the high ambiguity positive is so hard is that subjects actually tried to envision more than 75 configurations. Even so, ambiguity seems to be a reliable index of difficulty. Second, concreteness generally makes materials easier to comprehend, store and process. The proposition will be qualififed momentarily--"generally" will be specified in some detail. But the overall effect needs to be accounted for in providing an explanation for the high ambiguity positive exception. Third, negative concrete materials are difficult to process. This interesting result is reported in Smith (1981). In comparing memory for concrete versus abstract sentences with or without negatives, Smith shows that concrete negatives are hardest to recognize. The explanation for the loss of the usual facilitative effect of concreteness on memory is that with a negative in the sentence, imaging is ineffectual (try it: "he did not eat an apple"). The implication that negatives destroy imagic potential is a critical part of the explanation fo follow. A final premise is that logic is a verbal, abstract

enterprise. This proposition is founded on the nature of logic, not on any particular empirical data.

Concreteness usually makes categorical syllogisms easier to solve. What could interfere with this effect? Negatives, for one thing. Due to Smith (1981), we suspect that people cannot image negated sentences. If so, the presence of "not" must serve as a signal to avoid nonverbal processing. Subjects will therefore process concrete positives in their nonverbal coding systmes, but will handle concrete negatives and all abstract sentences in their verbal modalities. High ambiguity should also interfere with the general concreteness effect. With simple, low ambiguity problems, imagic processing apparently confers an advantage. But a high ambiguity problem (they averaged 78 possible meanings in the present study) can only be visualized after being considerably "simplified," and such streamlining will no doubt lead to logical errors. So verbal processing, the natural mode for logic, is the only hope for correct solutions to high ambiguity problems. If the high ambiguity problem is also abstract, this will occur naturally. But if it is concrete and positive, the concreteness will stimulate nonverbal processing, and reasoning will probably therefore be erroneous. A high ambiguity negative problem, however, will be handled verbally because of the "not" cue.

This characterization of people's cognitive processes has several implications. (1) Low and medium ambiguity problems are easier to solve than highs, given similar concreteness and negation conditions. This is the basic ambiguity effect. The sole exception to this prediction is that the medium ambiguity negative is harder than the high ambiguity negative in table 2; all other results support this generalization. (2) Presence of a negative makes easy concrete problems harder. In other words, the facilitative effect of concreteness is destroyed when the "not" cue appears. The prediction is relevant to low and medium ambiguity syllogisms, as we have seen, but not to high ambiguity ones, which

are too hard for concrete processing. Therefore, the test of this prediction is the contrast between high imagery negative and high imagery positive for the low and medium ambiguity conditions. The prediction is supported in tables 1 and 2; table 3 is irrelevant, and table 4 shows no advantage either way. (3) Presence of a negative makes hard concrete problems easier. This is predicted on the grounds that the "not" signal is powerful enough to overcome the spontaneous tendency to process concrete materials nonverbally. Difficult (i.e., high ambiguity) problems ought to be handled verbally. The test here is the contrast between high ambiguity positive and high ambiguity negative for high imagery. The prediction is supported in tables 1, 3 and 4; table 2 shows no advantage.

These three claims find clear support in the results of the four studies, and together explain the two most anomalous findings: the high ambiguity positive outcomes, and the discovery that negatives can make some problems easier. The account does not, however, quite explain all the circumstances which determine whether concrete problems will be easier than abstract ones.

How do these studies bear on dual coding theory? The simple corollary that abstract problems are easier to solve is certainly not supported in the unqualified form the theory (as opposed to some of the empirical findings on imagery) seems to require. The claim that nonverbal processing is alogical needs to be carefully reconsidered and modified. The studies do, however, support the general notion that concrete and abstract materials are processed differently (or at least with different outcome qualities), and suggest an interesting interpolation of negation into the theory.

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1. Jackson, S. Two models of syllogistic reasoning: An empirical comparison. Paper presented to the International Communication Association, Boston, 1982.

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TABLE 1

ANOVA Results and Means

Source	SS	df	MS	F	p	ω^2
Between Subjects	86.713	149	.582			
Within Subjects	583.389	2550	.229			
Negativity (N)	24.083	1	24.083	103.60	.000	.0356
Imagery (I)	21.132	2	10.566	46.02	.000	.0326
Ambiguity (A)	1.699	2	.849	4.61	.01	.0031
N x I	4.560	2	2.280	10.01	.000	.0075
N x A	8.149	2	4.074	22.78	.000	.0127
I x A	22.335	4	5.584	27.18	.000	.0345
N x I x A	6.578	4	1.644	10.50	.000	.0107
Residual	494.854	2533	.195			
Total	670.102	2699				

Grand Mean: .543

Marginal Means

Negativity:	N = .474
	P = .611
Imagery:	HI = .543
	MI = .527
	LI = .558
Ambiguity:	HA = .356
	MA = .641
	LA = .631

Cell Means

Negativity:		N			P		
Ambiguity:		LA	MA	HA	LA	MA	HA
Imagery:	HI	.567	.527	.460	.740	.747	.220
	MI	.460	.520	.333	.840	.747	.260
	LI	.413	.553	.433	.767	.753	.427

Note. Correct answers are scored as 1, incorrect responses as 0.

TABLE 2

Reanalyzed Cell Means for Wilkins (1928)

Negativity:		N			P		
Ambiguity:		LA	MA	HA	LA	MA	HA
Imagery:	HI	85.7	75.8	81.5	86.6	83.5	80.7
	LI	74.6	64.3	71.7	78.0	68.0	64.3

Note. Means represent percentages of correct answers.

TABLE 3

Reanalyzed Cells Means for Steinfatt, et al (1974)

Negativity:	N			P		
Ambiguity:	LA	MA	HA	LA	MA	HA
Means:	65.58	53.50	44.20	70.41	73.31	34.66

Note. Means represent percentages of correct answers.

TABLE 4

Reanalyzed Cells Means for Ceraso & Provitera (1971)

Negativity:		N		P	
Ambiguity:		LA	HA	LA	HA
Imagery:	HI	80.0	80.0	80.5	51.3

Note. Means represent percentages of correct answers.

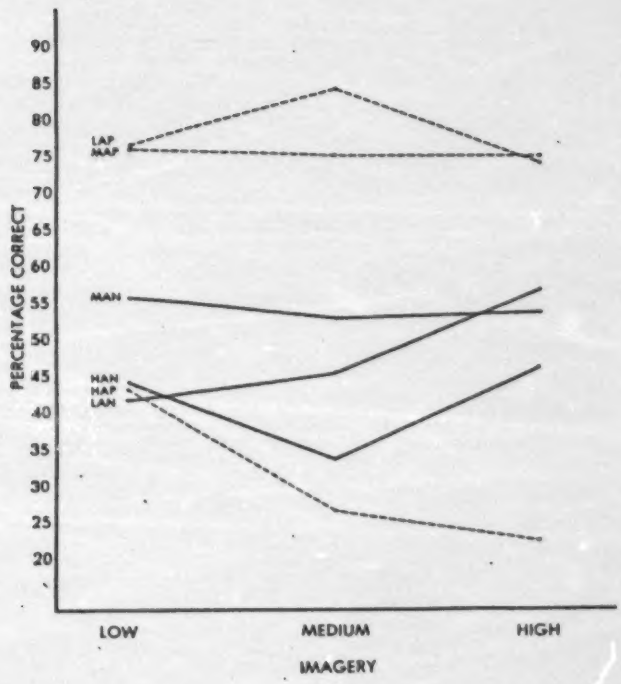
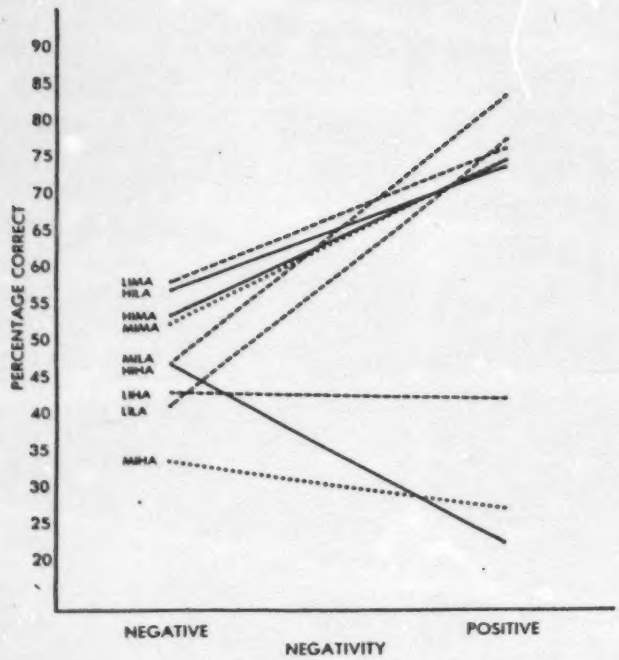


Figure 1. Experimental Results, Featuring Imagery Effects.



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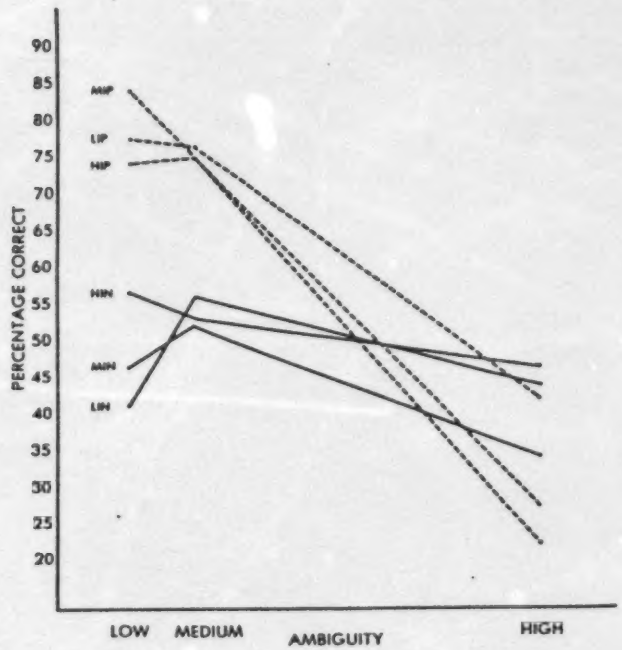

Figure 3. Experimental Results, Featuring Ambiguity Effects.

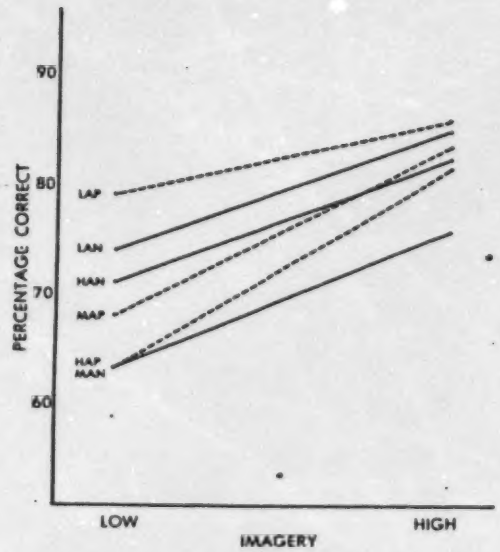

Figure 4. Reanalysis of Wilkins (1928), Featuring Imagery Effects.

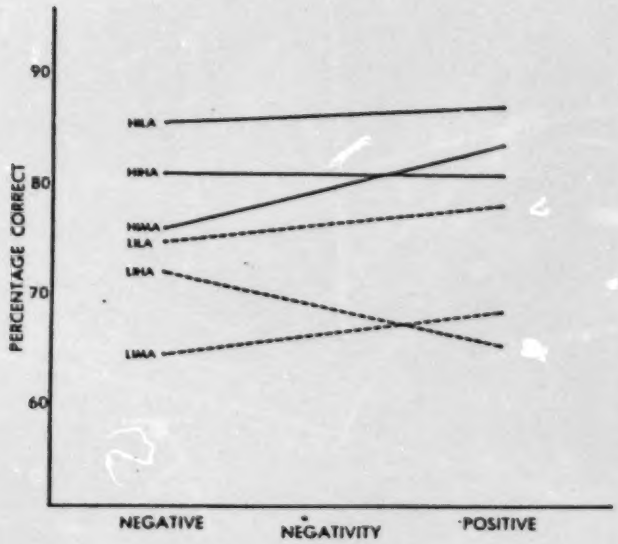

Figure 5. Reanalysis of Wilkins (1928), Featuring Negativity Effects.

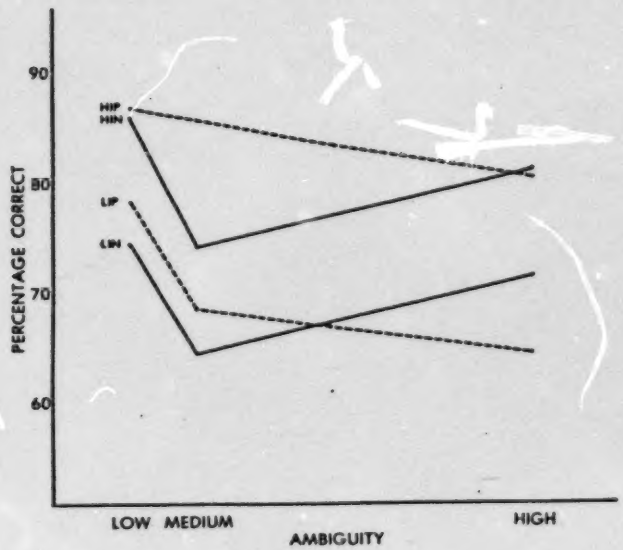

Figure 6. Reanalysis of Wilkins (1928), Featuring Ambiguity Effects.

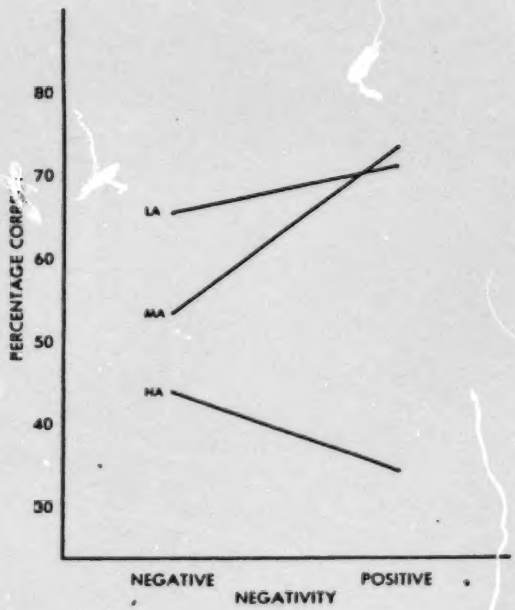

Figure 7. Reanalysis of Steinfatt, et al (1974), Featuring Negativity Effects.

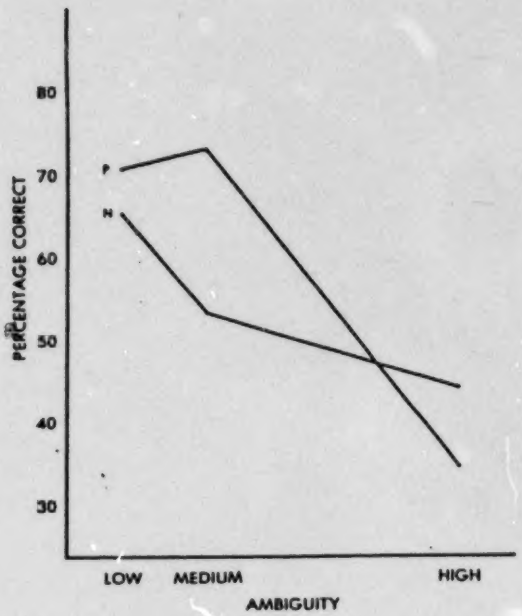

Figure 8. Reanalysis of Steinfatt, et al (1974), Featuring Ambiguity Effects.

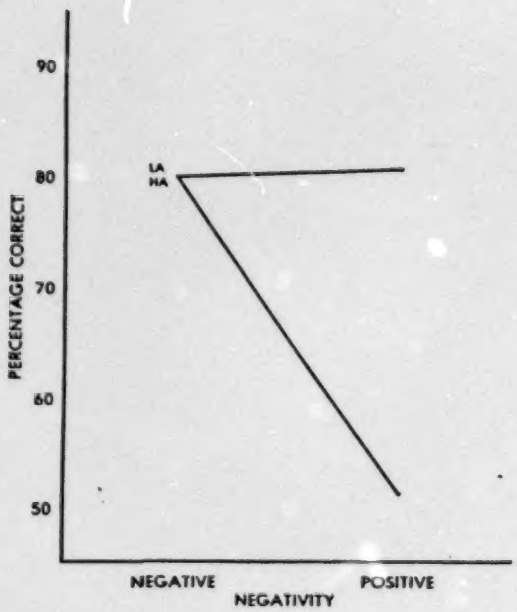

Figure 9. Reanalysis of Ceraso & Provitera (1971), Featuring Negativity Effects.

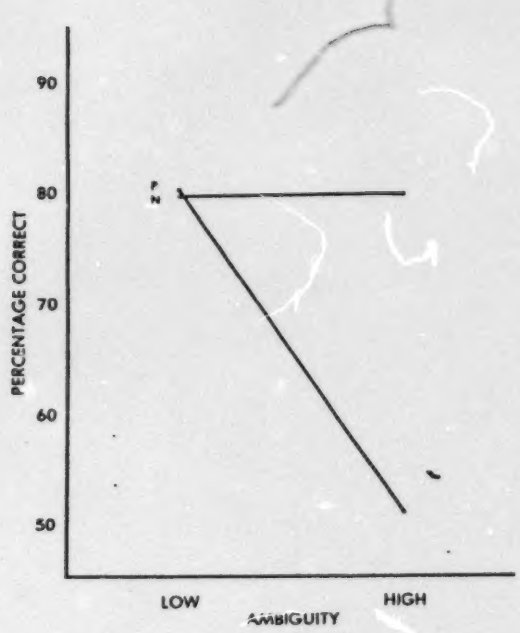

Figure 10. Reanalysis of Ceraso & Provitera (1971), Featuring Ambiguity Effects.